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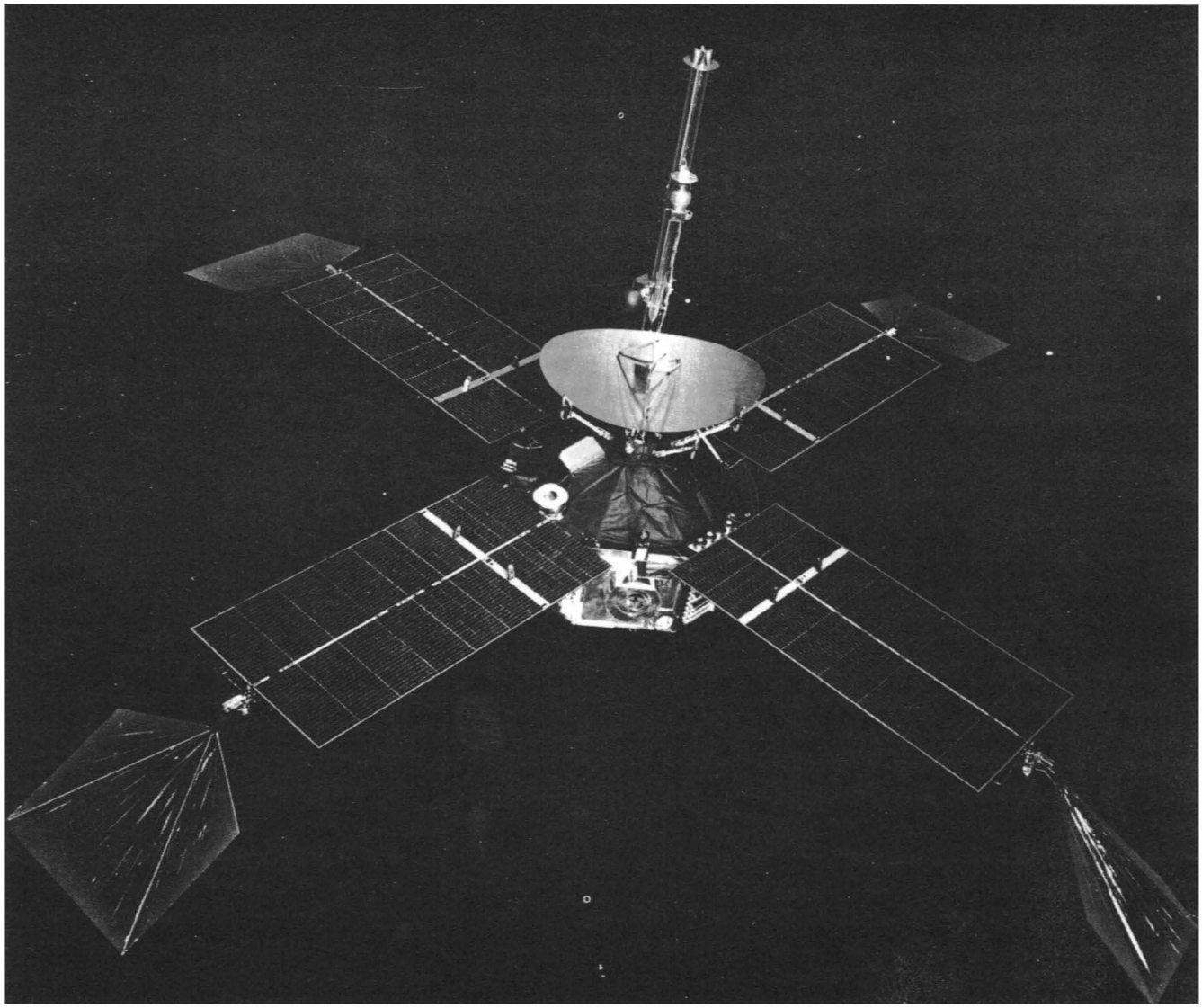
MARINER IV



Mariner IV spacecraft.

The United States has launched an unmanned spacecraft in the first American experiment to explore space farther from the sun than earth's orbit. The spacecraft, called Mariner IV, is equipped to report on space phenomena that it encounters and, if all goes well, to provide mankind with the first close look at Mars. The experiment also provides engineering experience in operation of spacecraft during prolonged flights away from the sun.

SCIENTIFIC INVESTIGATIONS

Mariner is equipped to carry out a broad range of investigations in interplanetary space and near Mars. The investigations include:

1. Ionization Chamber—The Mariner IV ionization chamber is a five-inch diameter sphere filled with argon gas. It is designed to measure the intensity of high-energy radiation, particularly cosmic rays. When cosmic ray particles (nuclei of hydrogen or helium atoms, nuclei of atoms heavier than hydrogen or helium, or electrons—originating principally outside of the solar system) penetrate the sphere, they strip electrons from the argon gas atoms, creating a trail of argon ions. The degree of ionization yields a measurement of the energy of the particles. A Geiger-Mueller Tube associated with the chamber furnishes a count of particles. Together, the instruments provide information on the density and energy levels of cosmic rays.

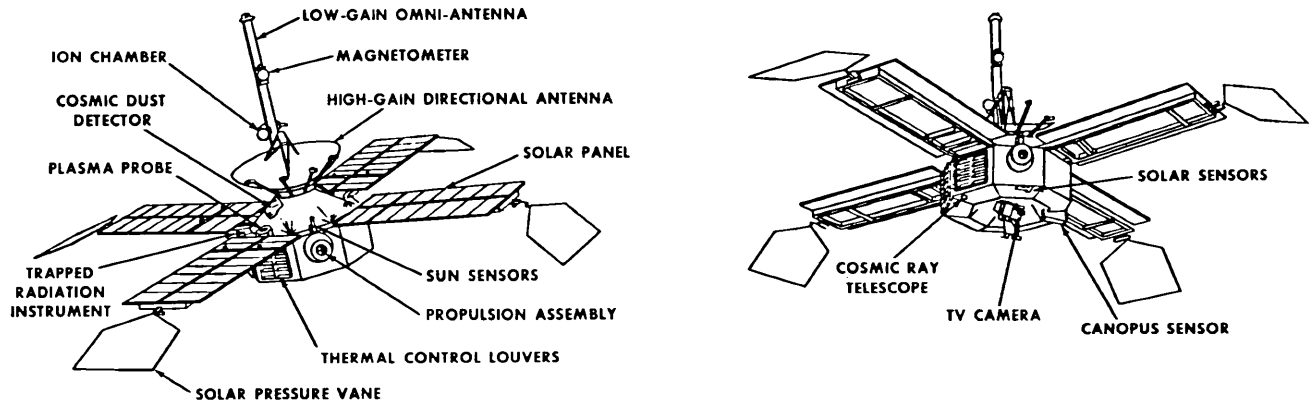
2. Trapped Radiation Detector—The principal purpose of this instrument is to report the existence, if any, of a radiation belt around Mars similar to the Van Allen Radiation Region around the earth. The Van Allen Region consists of atomic particles (chiefly electrons and protons) trapped in the lines of force of earth's magnetic field. The detector also reports on radiation in interplanetary space.

3. Cosmic Ray Telescope—This instrument analyzes in detail portions of the cosmic ray energy range covered by the ionization chamber (above). It also detects particles with lower energy. The instrument derives its name from the fact that its three detectors are arranged like the series of lenses in a telescope. The degree of a particle's penetration—i.e. through one, two, or three detectors—yields information relative to its energy.

4. Magnetometer—This instrument provides information on the strength and direction of magnetic fields in interplanetary space. It is also designed to determine the existence and nature of a magnetic field, if any, around Mars. Mariner II reported that magnetic fields were nearly always present in interplanetary space.

5. Micrometeoroid Detector—The micrometeoroid detector provides information on the distribution and momentum of tiny particles of matter in space. Mariner II reported relatively few micrometeoroids between earth and Venus. Mariner IV may encounter more meteoroids than Mariner II because it is flying toward the asteroids, one presumed source of micrometeoroids. In addition, Mariner IV passed through three meteoroid streams. In December 1964, the spacecraft flew through the Geminid and Ursid meteor streams. In March 1965, it passed through the Tuttle-Giacobini-Kresak stream. (The asteroids are a swarm of small celestial bodies in solar orbit, largely between the orbits of Mars and Jupiter. The three meteor streams are believed to be composed of particles once making up the nucleus of a comet. Both asteroids and comets have been said to be sources of meteoroids.)

6. Solar Plasma Probe—This instrument was included in Mariner IV's series of experiments to measure the density, velocity, temperature, and direction of the solar plasma between earth and Mars. Mariner II showed the plasma to be a predominant feature of the interplanetary space environment through which the spacecraft



Two views of the Mariner IV spacecraft, showing locations of principal parts.

flew. The plasma significantly influenced cosmic rays and magnetic fields. Solar plasma is a boiling off of the sun's atmosphere. It is a high velocity, high temperature electrified gas (hydrogen or helium).

7. Occultation Experiment—The trajectory, or flight path, of Mariner IV will carry the spacecraft behind Mars relative to earth. The manner in which Mariner's radio transmissions are distorted by the Martian atmosphere as the spacecraft flies behind the planet can indicate the atmosphere's density.

8. Television Camera—Mariner is expected to reach the vicinity of Mars at 9:11 p.m. EDT, July 14, 1965, and draw as near as about 5,000 miles to the planet. While passing Mars, Mariner's television cameras will snap up to 22 black and white close-ups of the Martian surface for later telecast to earth. The strip of pictures is expected to show terrain features as much as 50 times smaller than those visible from earth.

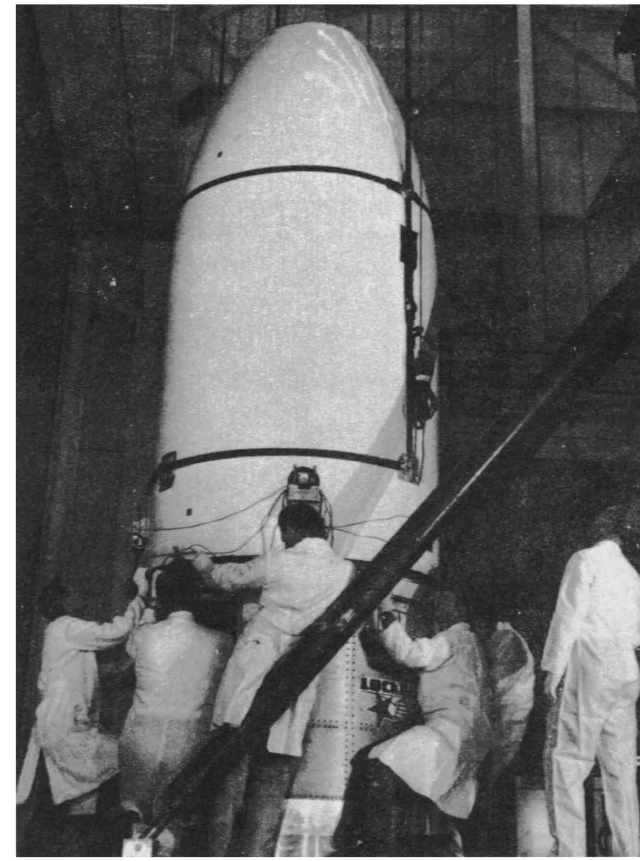
SPACECRAFT DESCRIPTION

Mariner IV is basically an octagonally shaped structure 50 inches across. In and on this structure are attached the solar panels that generate electric power for spacecraft operation, communication equipment, experiments, a rocket engine for course changes, an orientation and stabilization system, and other components.

On earth, Mariner IV weighs 575 pounds. In space, with appendages deployed, Mariner spans 22 feet 7½ inches across its solar panels and solar vanes (see below) and extends 9½ feet from the base of the octagonal structure to the tip of the omni-antenna (an antenna that radiates radio signals in all directions).

Mariner IV has four solar panels as compared to the two with which Mariner II and the Ranger lunar spacecraft were equipped. This is intended to compensate for the decreasing intensity of sunlight with increasing distance from the sun. At the orbit of Mars, sunlight is only half as bright as at the orbit of earth.

The panels hold a total of 28,224 solar cells that convert sunlight to electric power. In addition, Mariner is equipped with a storage battery which provides power when the panels are not facing the sun (as during a course correction) and serves as a back-up during peak power demands. The battery is recharged by the solar panels.



Aerodynamic shroud, which protected Mariner IV during launch through the atmosphere, is tested.

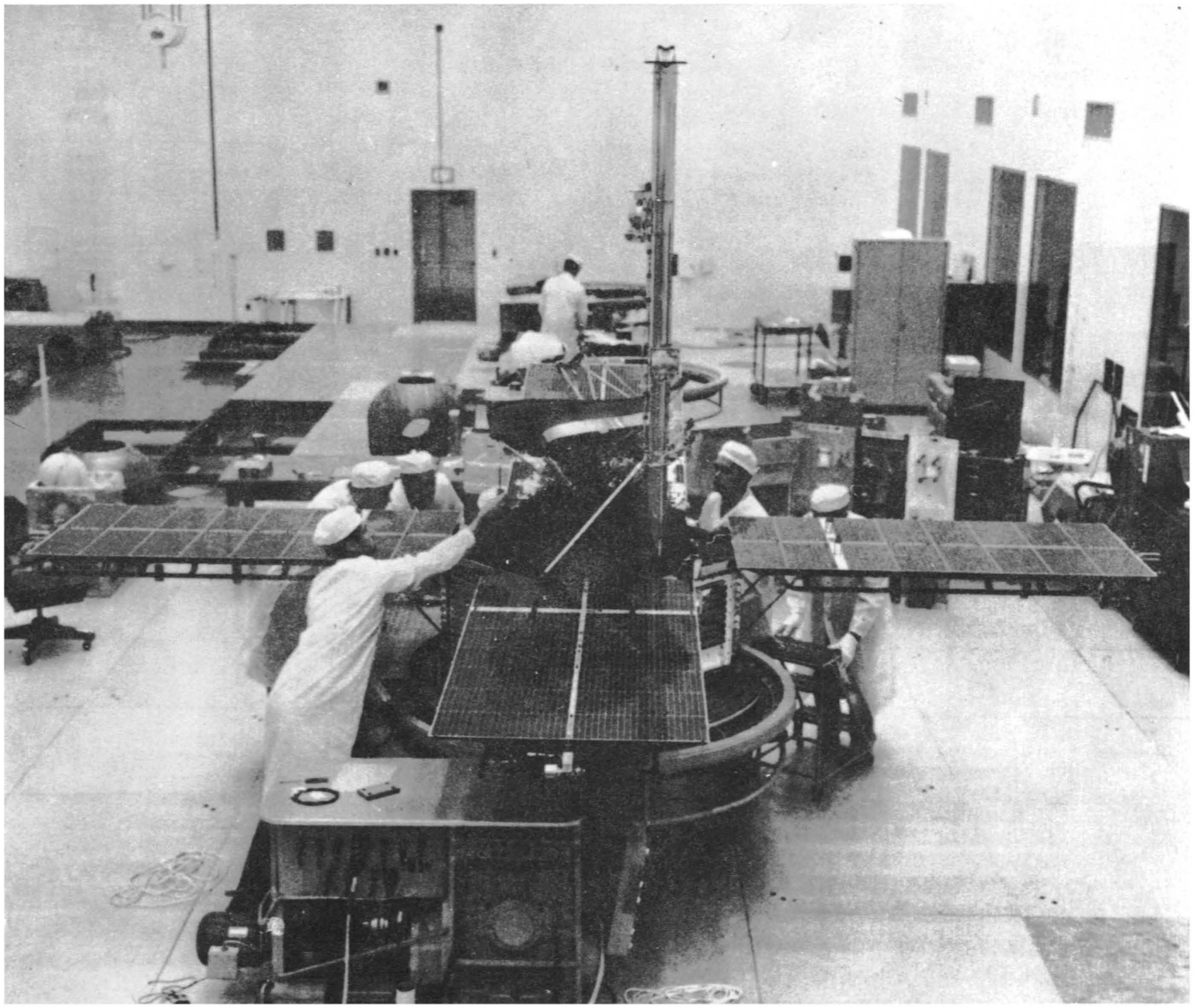
Solar pressure vanes attached to the ends of the solar panels balance out the faint pressure of the solar radiation by increasing or decreasing the area of the craft that faces the sun. They are an auxiliary attitude, or orientation, control system.

The primary attitude control system consists

MARINER III

Mariner III, launched toward Mars on November 5, 1964, failed when a new kind of shroud did not jettison as planned. The shroud covers a spacecraft and protects it from aerodynamic forces, such as the rush of air, created during launch.

Engineers designed, built, and tested another kind of shroud for Mariner IV. This shroud operated properly.



Solar panels of Mariner IV are attached.

of nitrogen gas jets linked to three gyroscopes, sun sensors, and a Canopus star sensor. The system is designed to keep the high-gain antenna (an antenna that focusses radio beams in a single direction, thereby providing maximum strength for receivers) pointed to earth, the solar panels facing the sun, and the television camera aimed at Mars when Mariner reaches the planet's vicinity. This attitude also provides a reference point from which the craft can be reoriented for midcourse guidance.

The sun sensor is a light-sensitive device that generates an electric impulse when Mariner's solar panels are not receiving maximum sunlight. The pulse activates gas jets, which turn the craft to the sun.

The Canopus sensor is a photomultiplier tube. In such an instrument, light striking a grid knocks off electrons which in turn knock off more electrons in succeeding grids. This results in amplification of the light in the form of a measurable electric current.

The sensor is set to respond to light in the intensity range of the star Canopus. However, the lower end of this range grazes the brightness of other celestial objects. Moreover loss of the lock on Canopus could be caused by dust particles drifting between the sensor and Canopus

and reflecting a flash of sunlight into the sensor. As a result, planners incorporated into Mariner IV a system by which it could be commanded from earth to search for Canopus.

Canopus is the second brightest star in the sky, exceeded in brilliance only by Sirius. It is about 100 light years or 600 trillion miles from earth. It is a Southern Hemisphere star, visible no farther north than about 30 degrees latitude North (Florida).

The star was chosen as a reference point because it is located at about a 90 degree angle from the sun (another reference point) and is relatively isolated from other bright stars.

This is the first use of Canopus as a reference point. Mariner IV does not use earth as a reference point as did Mariner II and the Ranger lunar spacecraft. One reason is that the earth is in front of and shadowed by the sun relative to Mariner IV.

Ground personnel know when the Canopus lock is achieved by analyzing the radio signals into which the electric currents of the star sensor have been converted. The signals should match a predicted value for Canopus.

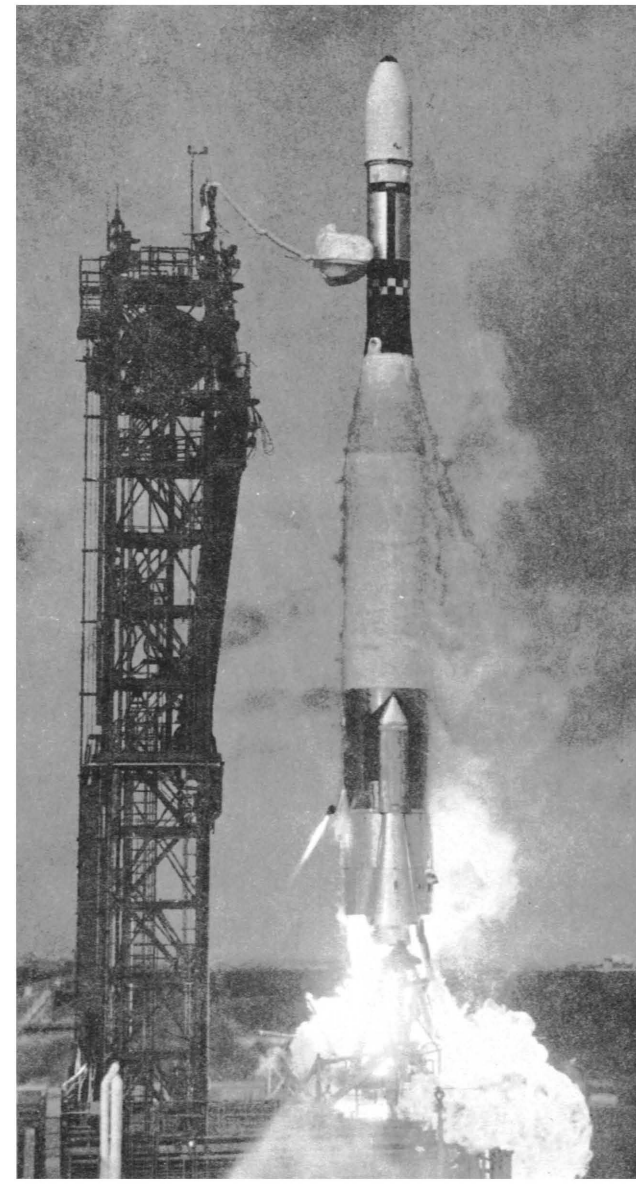
Altogether, Mariner IV is made up of 138,000 components. For Mariner to accomplish all of its goals, the components must remain functional for a minimum period of about nine months as the spacecraft hurtles approximately 350 million miles through the hostile environment of space.

FIRST JOURNEY FROM THE SUN

The Mariner experiment is the first in which American spacecraft have been launched in a flight away from the sun. As a result, the experiment provides the first experience in building and operating spacecraft for such missions.

Mariner IV began its approximately 350-million-mile journey when its Atlas-Agena booster launched it into a low earth orbit at a speed of about 18,000 miles per hour (mph). At the proper location in this orbit, the still attached Agena second stage ignited and propelled Mariner toward Mars at 25,598 mph.

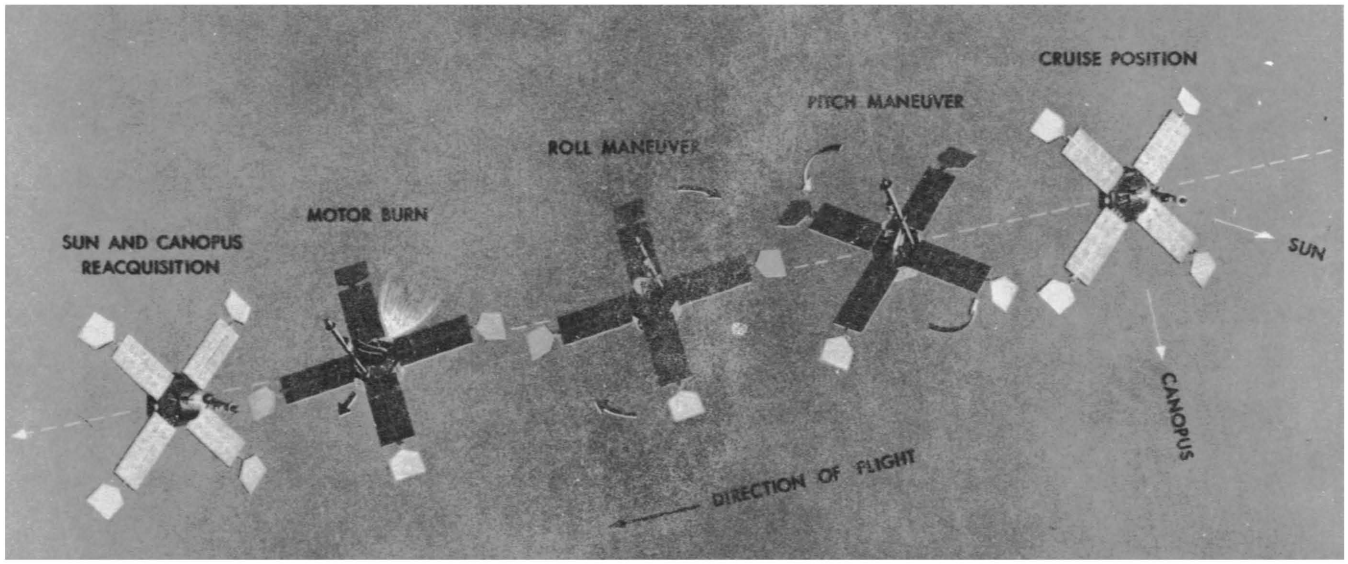
This speed relative to earth is not maintained. For example, at a distance of 122,000 miles, Mariner is pulling away from earth at a rate of about 8,000 mph. Although earth's gravity can never pull Mariner back to earth, its influence does slow Mariner down.



Atlas-Agena booster launches Mariner IV.

At this point, however, the important speed is that of Mariner relative to the sun. Mariner is hurtling through space at a speed of about 74,000 mph relative to the sun in an orbit that intersects the orbits of Mars and earth. (Earth's orbital velocity relative to the sun is about 66,000 mph; Mars' 54,000 mph.)

A planned event of the Mariner IV flight is a midcourse correction of its trajectory. This is necessary because an error of just one mile per hour, for example, in the execution of the launch can result in a 9,000-mile miss of the target. Mariner is equipped with a 50-pound thrust rocket motor which can be fired twice for course corrections. (Rocket motors of Ranger and Mariner II could be fired only once.)



Mariner IV midcourse maneuver.

At the time of its midcourse maneuver on December 5, 1964, Mariner was 1,267,613 miles from earth. Its velocity was 7,019 mph relative to earth and 74,108 mph relative to the sun. If it continued on its original flight path, it would pass Mars at a distance of about 151,000 miles, too far to provide significant information about the planet.

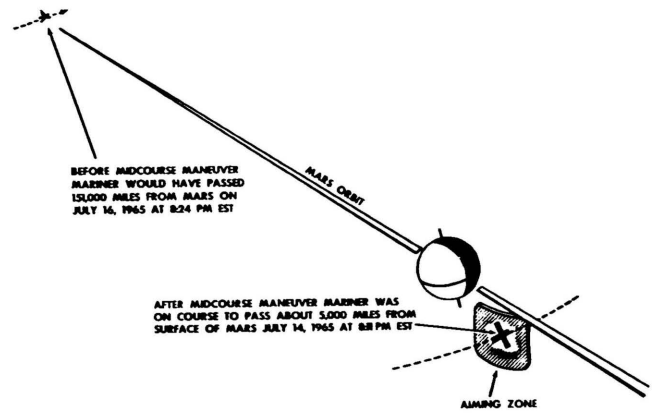
For the maneuver, Mariner IV executed the following commands radioed from earth: pitch turn of minus 39.2 degrees; a roll of 156.08 degrees; and rocket firing for 20.06 seconds (see illustration).

The maneuver added 28 mph to Mariner's speed relative to earth. Because of the vast distance involved, it changed Mariner's arrival date at Mars orbit from July 16, 1965, to July 14, 1965. Instead of passing 151,000 miles in front of Mars, Mariner will pass about 5,000 miles behind Mars.

After the maneuver, Mariner locked on the star Gamma Velorum, near Canopus which is the Mariner star sensor's proper reference point. On December 17, Mariner, on command from earth, rolled, searched for, and reacquired Canopus.

LAUNCH WINDOW

A launch window is defined as a period of time during which a craft can be launched and meet its objective. The launch window for Mars shots occurs every 25 months and lasts several weeks.

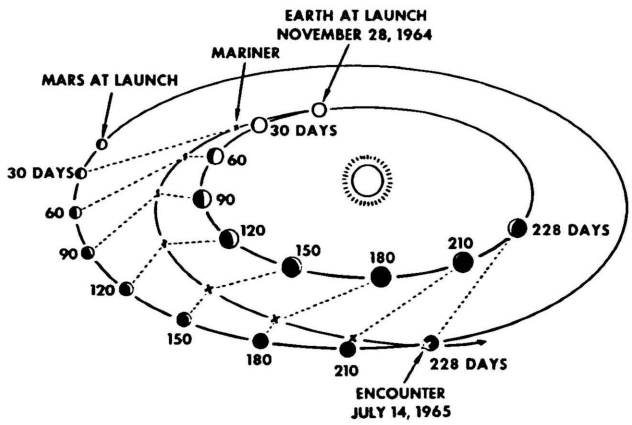


Results of Mariner IV midcourse maneuver.

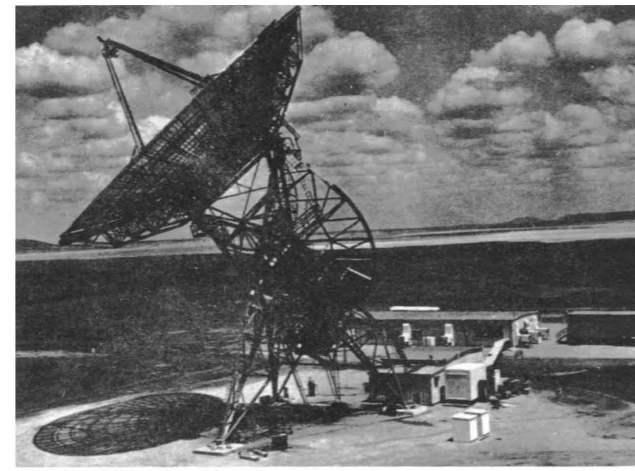
Mariner is aimed to pass rather than land on Mars. If Mariner struck Mars, it would have relatively little time for close-up observation and sending this information to earth. Moreover, it could land earth microorganisms on the planet, a prospect that scientists are anxious to avoid.

Earth and Mars are about 134 million miles apart when Mariner makes its planetary observations. Mariner snaps each picture of the Martian surface in a fraction of a second. Then, Mariner transforms the pictures into electrical impulses that are recorded on magnetic tape, in much the same way as television studios tape shows for future presentation. Because of the limited power available on Mariner and the great

MARINER TRAJECTORY TO MARS



Mariner's path to Mars.



85-foot diameter antenna of the Deep Space station at Woomera, Australia.

distances involved, the spacecraft takes slightly more than 8 hours to transmit a single picture.

Mariner transmits at 10 watts as compared to the approximately 100,000 watts or more at which a typical metropolitan television station on earth transmits its video signal (picture). Ground stations with 85-foot diameter antennas amplify Mariner's extremely faint signals to useful strength.

The Mariner-earth communication system can handle 8.3 bits (units of information) per second over the distances anticipated in the Mars experiment (as far as 150 million miles). It takes about 250,000 bits, or more than 8 hours, to return the shadings of each photograph. If Mariner telecasts three pictures per day to earth, it would take more than a week to receive all of them. In between sending pictures, Mariner also relays information about the space environment near and beyond Mars.

NASA's global Deep Space Network tracks, commands, and acquires data from Mariner IV. The network consists primarily of four installations equipped with 85-foot diameter antennas. Two are located at Goldstone, California; one is at Johannesburg, Republic of South Africa; and the fourth is at Woomera, Australia. The stations are so spaced that one or more can maintain contact with Mariner despite the earth's rotation.

On November 30, 1964, the Soviet Union announced the launch of the Zond 2 spacecraft toward Mars. Zond is Russian for probe. The Soviet Union subsequently reported that trouble had developed with the spacecraft's power system.

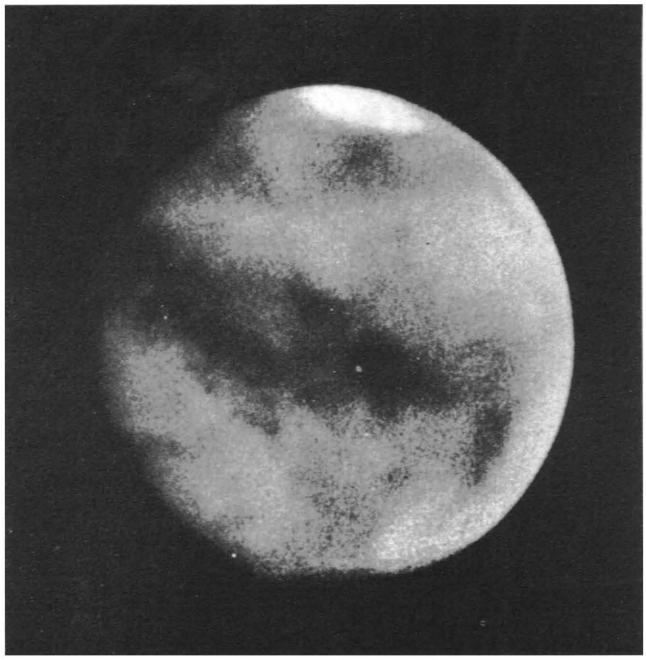
MARS

Of all the other planets in the solar system, Mars appears to be the most likely to harbor some sort of life like that on earth. However, man's observations of Mars have been made from a distance of no less than 36 million miles. As a result, scientists can seriously debate the implications of such observations.

For example, the surface of Mars changes color with the seasons. The changes appear to correlate with increases and decreases of the

SOME MARINER MISSION COMPARISONS

	VENUS—1962	MARS—1964
Launch period available	51 days	30 days
Flight time to planet	109 days	228 days
Flight time to complete mission	109 days	238–248 days
Communications distance at planetary encounter	36 million miles	134 million miles
Communications distance to complete mission	36 million miles	150 million miles
Distance from sun on reaching planet	67 million miles	145 million miles
Spacecraft weight	447 pounds	575 pounds
Number of parts in spacecraft	54,000	138,000
Attitude references	Sun and earth	Sun and Canopus
Solar panel area	30 square feet	70 square feet
Data transmission	Real time (immediately)	Real time and storage
Course correction capability	1 time	2 times



Mars through a telescope on earth. Mariner IV may provide topographic pictures as much as 50 times more detailed than those made from earth.

bright polar caps which are thought to be made up of thin layers of frost. The darkening observed when the polar caps appear to melt could indicate vegetation responding to moisture. However, since certain inorganic substances such as salt also darken when wet, the areas that darken could be salt flats.

Some astronomers have noted strange spots on the Martian surface that change size and shape as if they were alive. Still others have claimed to see "canals" which would have to be the work of intelligent beings. However, other scientists consider the "canals" subjective illusions.

Spectographic observations, through which matter is identified by its absorption and emission of light, suggest existence of organic materials. However, scientists know that organic materials could arise through non-biological processes. Moreover, the spectroscopic studies reveal none of the characteristics of green chlorophyll. And studies show that the dark areas warm up during the Martian day and cool off during the Martian night as rapidly as other areas. These would not be typical of plant life as we know it.

Analyses of the planet's atmosphere have produced conflicting results. Generally, it is believed high in carbon dioxide and nitrogen and low in oxygen and water vapor. Its density at the Martian surface is estimated at anywhere from 10 to 100 millibars. This is about one to 10 percent of the pressure at earth's surface. More definite information on density of the Martian atmosphere is essential for design of craft intended for soft landings on that planet.

Among the puzzling Martian phenomena is the blue haze which generally envelops the planet and which from time to time mysteriously disappears.

Science has gathered many facts about Mars. Its mean distance from the sun is calculated at 141 million miles, compared to earth's 93 million miles. Its temperatures at the equator range from 50 degrees Fahrenheit at the Martian noon to 90 degrees below zero Fahrenheit at night. (Such a temperature range does not make life prohibitive.)

The Martian year, or time for Mars to circle the sun, is 687 days. The Martian day, or time for a complete rotation on its axis, is 24 hours 37 minutes, almost the same as earth's. Like earth too, Mars tilts on its axis and, therefore, has seasons.

Mars has a diameter of 4,140 miles, about half that of earth. Its gravity pull is .38 that of earth, meaning a 100-pound object on earth would weigh 38 pounds on Mars.

It has two small satellites: Phobos (diameter 12 miles) and Deimos (diameter 6 miles). Their small sizes, low altitudes (less than 15,000 miles), and peculiarity of their movements around Mars have led to much speculation about their nature and origin.

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